2.6.2 ION EXCHANGE

The Ion Exchange alternative would use crystalline silicotitanate resin in ion exchange columns to separate cesium from the salt solution. The salt solution would be passed through large stainless steel ion exchange columns filled with the ion exchange resin to react the cesium with the resin. Treatment of the solution with monosodium titanate to separate strontium and actinides, and filtration to remove the solids and residual sludge, would be necessary prior to separating the cesium to prevent plugging the ion exchange columns.

Both the monosodium titanate solids and the cesium-loaded crystalline silicotitanate resin would be transferred to DWPF for vitrification. The low activity salt solution would be transferred to the Saltstone Manufacturing and Disposal Facility for disposal as grout in onsite vaults.

Process flows for the Ion Exchange alternative are shown in Figure 2-5.

The Ion Exchange process would result in the accumulation of as much as 15 million curies of radioactive cesium on the resin inventory within the process cell. This radioactive loading would necessitate stringent shielding requirements and operational controls because of high radioactivity, high heat generation, and the generation of hydrogen and other gases.

2.6.3 SOLVENT EXTRACTION

Solvent Extraction is DOE's preferred alternative. The Solvent Extraction alternative would use a highly specific organic **extractant** to separate cesium from the HLW salt solution. The cesium would be transferred from the aqueous salt solution into an insoluble organic phase, using a centrifugal contactor to provide high surface area contact, followed by centrifugal separation of the two phases. Recovery of the cesium by **back extraction** from the organic phase into a secondary aqueous phase would generate a concentrated cesium solution (**strip effluent**) for vitrification in DWPF. Prior treatment of the HLW salt solution, using monosodium titanate to separate soluble strontium and actinides and filtration to remove the solids and residual sludge, would be required to meet salt solution decontamination requirements and avoid interference in the solvent extraction process. The monosodium titanate solids would be transferred to DWPF for vitrification along with the strip effluent solution. The low-activity salt solution would be transferred to the Saltstone Manufacturing and Disposal Facility for disposal as grout in onsite vaults. TC

Process flows for the Solvent Extraction alternative are shown in Figure 2-6.

2.6.4 DIRECT DISPOSAL IN GROUT

Under the Direct Disposal in Grout alternative, the HLW salt solution would be disposed of onsite as saltstone, without prior separation of radioactive cesium. Before solidifying the salt solution as grout, monosodium titanate would be used to remove the strontium and actinides to meet saltstone waste acceptance criteria as a low-level waste. MST processing would be the same as that used in the Ion Exchange and Solvent Extraction alternatives. Equipment required is shown in Figure 2-7 (and in Appendix A). These include the alpha sorption tank and filter unit to separate the MST-sorbed constituents. The monosodium titanate slurry would be transferred to DWPF for incorporation into HLW glass. L6-45

After the monosodium titanate treatment, the clarified salt solution would be combined with **flyash**, **cement** and **slag** in a grout mixer for disposal in the saltstone vaults. The resulting sandstone would have radionuclide concentrations less than Class C LLW, but would exceed Class A limits, as defined in NRC regulations at 10 CFR 61.55. These waste classifications are not generally applicable to DOE-generated LLW. However, the NRC classification system is used in this SEIS to describe differences in the waste form because DOE Manual 435.1-1 establishes a process for making waste incidental to reprocessing determinations using the NRC Classification System at 10 CFR 61.55. The current saltstone permit, which was issued by TC

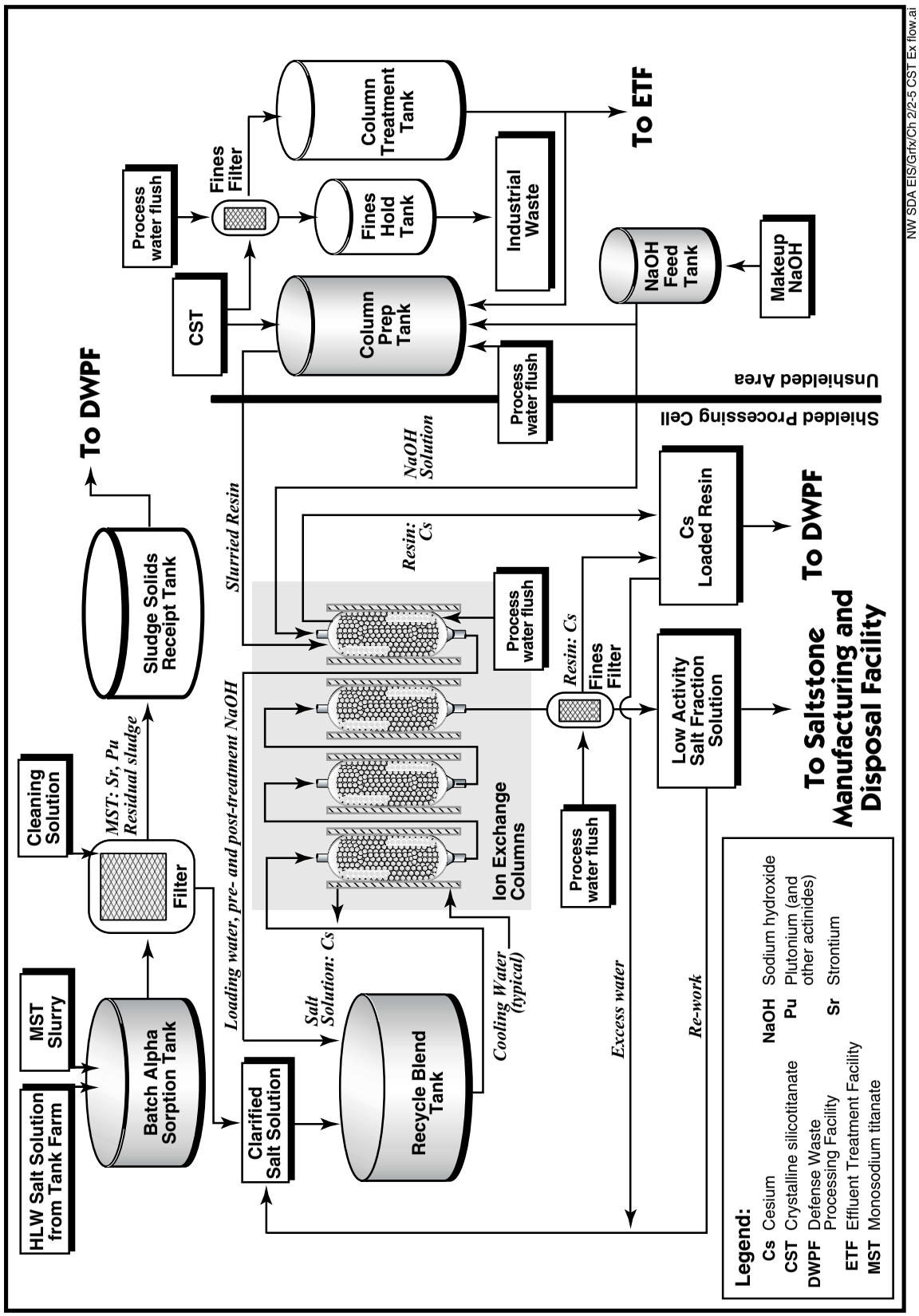

Figure 2-5. Ion Exchange process flow diagram.

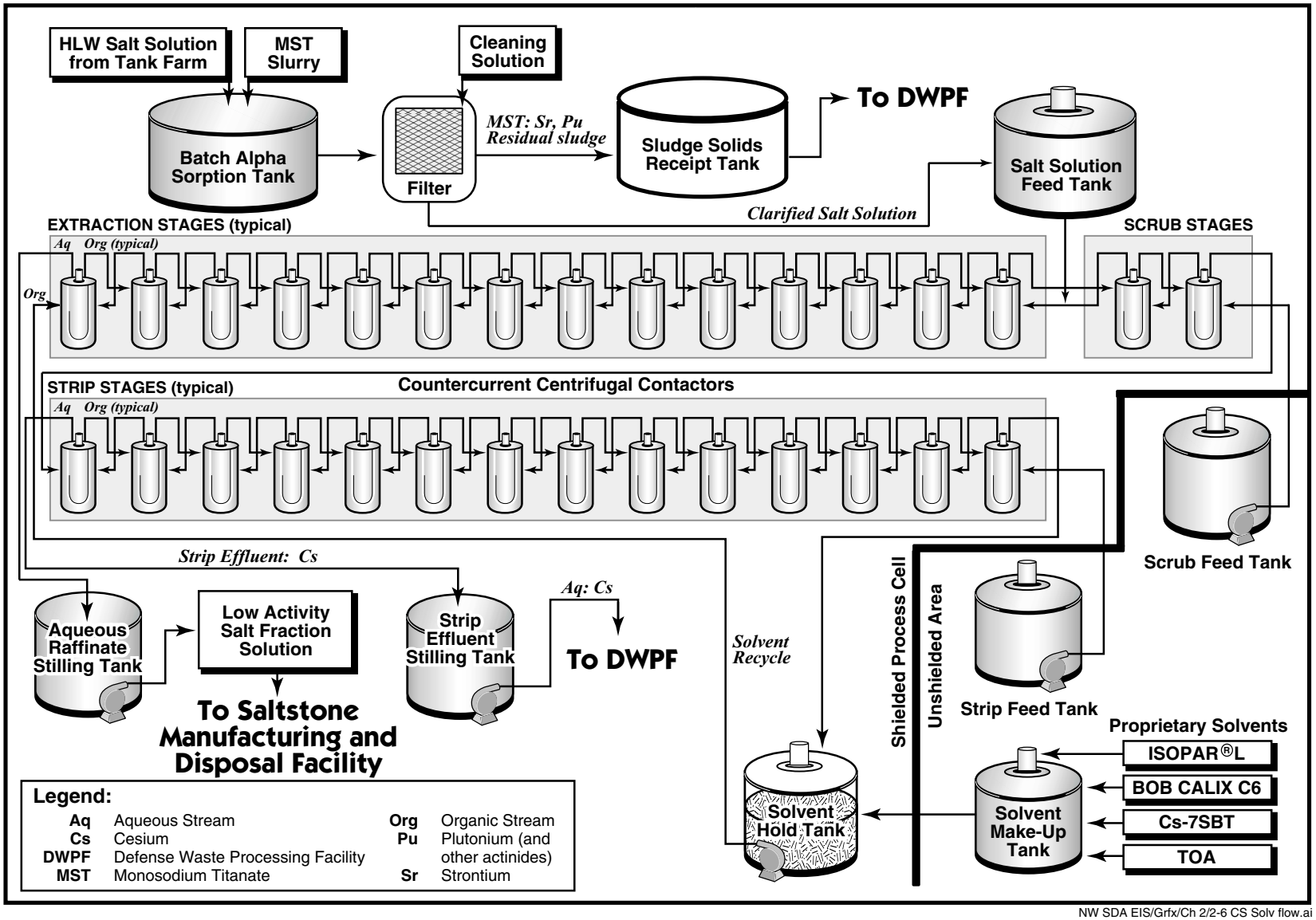

Figure 2-6. Solvent Extraction process flow diagram.

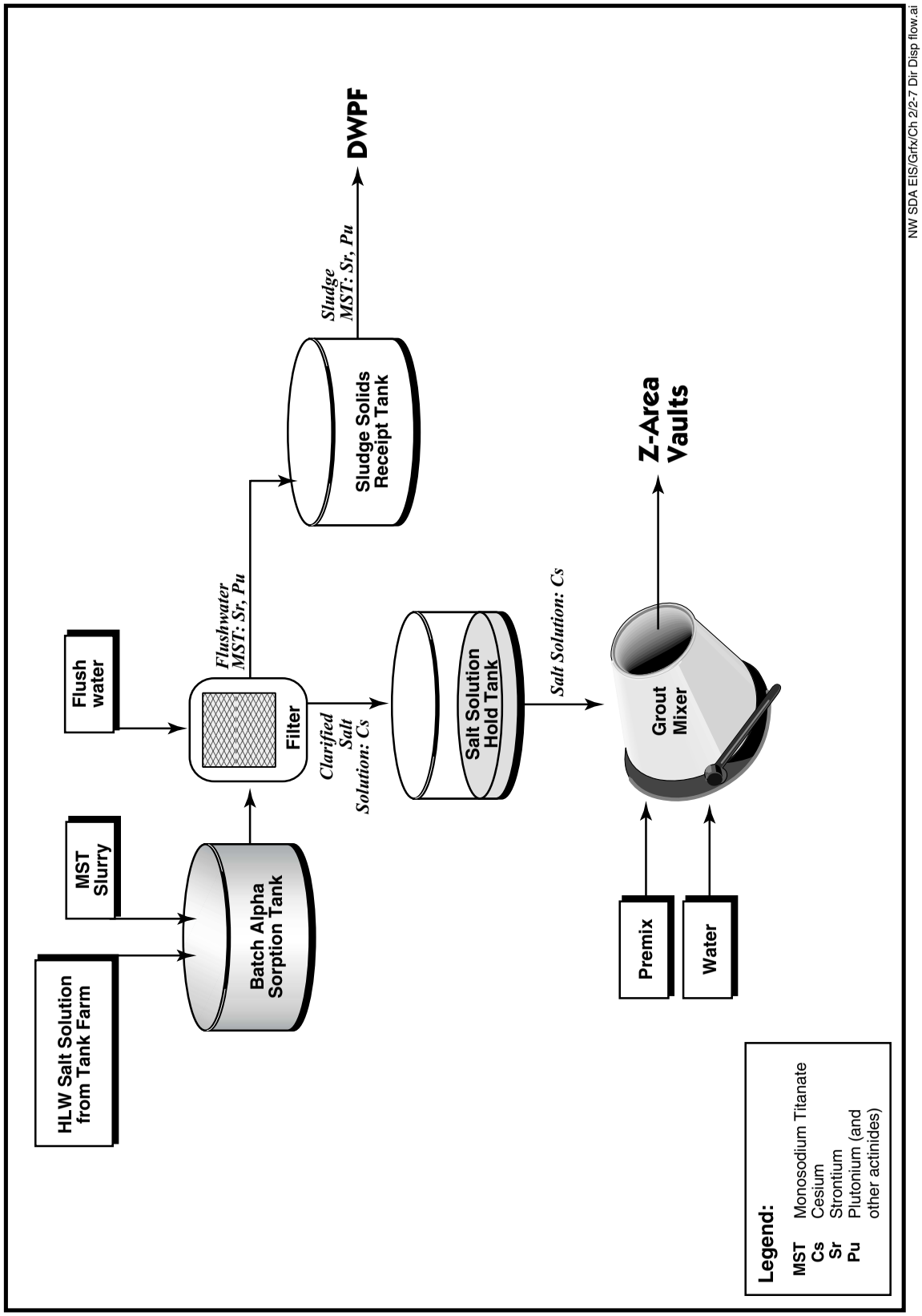

Figure 2-7. Direct Disposal in Grout process flow diagram.

SCDHEC under its State wastewater authority, authorizes disposal of wastes with radionuclide concentrations comparable to Class A LLW. Under the permit, DOE must notify SCDHEC if the characteristics of wastes in saltstone vaults would change, as would be the case with the higher level of radioactivity in the final waste form under the Direct Disposal in Grout alternative. TC

Process flows for the Direct Disposal in Grout alternative are shown in Figure 2-7.

2.7 Salt Processing Facilities

2.7.1 PROCESS INPUTS AND PROCESSING REQUIREMENTS

Design of salt processing facilities depends on specifications of processing requirements, including process input and product output. Volumes of input streams and requirements for their processing to final forms are summarized in Table 2-3. The capacities of the process facilities are specified to maintain an average processing rate of about 6 million gallons of waste salt solution per year at 75 percent attainment, allowing complete processing of about 80 million gallons total (approximate volume of salt solution when the saltcake is dissolved) within about 13 years after facility startup (WSRC 1999b). The throughput of all action alternatives is limited to 6 million gallons per year due to the physical constraints on removing waste from the waste tanks. It is important to finish processing the salt waste within this time so that the HLW sludge and the high-activity fraction of the HLW salt can be vitrified together in the DWPF. If salt processing is delayed beyond 2010 so that salt waste must be vitrified separately, the total number of HLW canisters would be increased over that projected for concurrent sludge-salt waste vitrification. Vitrification of the combined HLW sludge and salt would produce about 5,700 glass waste canisters. Preliminary projections indicate that if the salt processing initiation date of 2010 is not met, then the potential exists that up to 150 additional canisters (salt-only) per year would have to be produced for every year startup is delayed beyond 2010. The cost for additional canister production would be about $300 million per year. In the event sludge processing were to be completed prior to the initiation of salt processing, it would take 13 years (at 150 canisters per year) to process all of the salt waste at an approximate cost of $4 billion, in addition to the cost of constructing and operating the salt processing facility. (These costs do not include federal repository cost for transportation and disposal).

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Differences in the total number of combined sludge and salt waste canisters produced from the different salt processing alternatives would be small because of the relatively minor contribution of HLW salt compared to HLW sludge in the glass waste form. As many as 16 saltstone vaults in addition to the two existing vaults would be required for final disposal of the low-activity salt solution.

2.7.2 PRODUCT OUTPUTS

The product outputs from the process facilities, including high-radioactivity solids slurry or solution to DWPF, low-activity salt solution to grout, and saltstone generated by the salt processing alternatives are compared in Table 2-4. The Solvent Extraction facility would deliver a greater volume of product to DWPF than the other facilities because of the relatively high volume of cesium solution (strip effluent) in its product output. However, the amount of sludge processed at DWPF is the primary determinant for canister production. The difference in product volume delivered to DWPF from the Solvent Extraction alternative has little effect on the number of DWPF canisters produced because of the low solids content of the strip effluent stream. The salt solution to grout and product grout produced would be about the same for each alternative, within the uncertainties on the material balance estimates. TC

In addition to the principal product outputs specified in Table 2-4, the Small Tank Precipitation process would generate by-product

Table 2-3. Inputs and processing requirements for the salt processing alternatives.

	Alternative			
	Small Tank Precipitation	Ion Exchange	Solvent Extraction	Direct Disposal in Grout
Required processing rate (million gallons per year)[a,b]	6.9	6.9	6.9	6.0
Long-term average throughput of salt solution at 75% attainment (million gallons per year)[a,b]	6.0	6.0	6.0	6.0
Throughput limitation[a]	Salt removal rate from waste tanks	Salt removal rate from waste tanks	Salt removal rate from waste tanks	Salt removal rate from waste tanks
Number of years for construction of process facilities[c]	4.0	4.2	4.0	3.9
Number of years for startup testing	1.3	1.3	1.3	1.3
Number of years of facility operations	13[d]	13[e]	13[f]	13[g]
Planned canister production per year[h,i]	225 (average)	225 (average)	225 (average)	225 (average)
Canisters produced[h,i]	≈5,700	≈5,700	≈5,700	≈5,700
New Class A vaults[j]	16[d]	13[e]	15[k]	0[g]
New Class C vaults[j]	0[d]	0[e]	0	13[g]

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a. WSRC (1998b).
b. The required processing rate for the salt processing facilities exceeds the long term average throughputs to allow for downtime when DWPF is in an outage, except for the Direct Disposal in Grout facility which can operate at the required salt removal rate even when DWPF is not operating.
c. WSRC (1998c).
d. WSRC (1998d, 2000a).
e. WSRC (1998e).
f. WSRC (1998f).
g. WSRC (1998g).
h. WSRC (2000a) target case.
i. DWPF planned glass waste canister production includes both sludge and salt wastes.
j. New saltstone vaults for onsite disposal of processed salt solution.
k. This alternative would require between 14 and 15 vaults (WSRC 1998f); for purposes of impact analysis, 15 vaults were assumed.

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benzene. About 60,000 gallons per year (200 metric tons per year) of liquid benzene would be produced by decomposition of the tetraphenylborate salt in the precipitate hydrolysis process, to be stored for incineration and disposal.

The Solvent Extraction process would generate a liquid organic solvent also requiring final processing by incineration and disposal. The total **solvent** inventory for the process would be a projected 1,000 gallons. This inventory is conservatively assumed to be replaced once per year. For a tentatively assigned operational time of 13 years, the accumulated total volume of solvent requiring storage and disposal would be 13,000 gallons.

2.7.3 PROCESS FACILITIES

DOE would construct a new shielded facility to house chemical processing equipment (tanks,

Table 2-4. Product outputs for the salt processing alternatives.

	Alternative			
	Small Tank Precipitation[a]	Ion Exchange[b]	Solvent Extraction[c]	Direct Disposal in Grout[d]
Solids Slurry (and solution) to DWPF				
Annual (million gallons)	0.22	0.20	0.68[e]	0.15
Life cycle (million gallons)	2.9	2.6[f]	8.8[e]	2.0
Salt solution to grout				
Annual (million gallons)	8	6.6	7.5	5.9
Life cycle (million gallons)	100	86	97	77
Grout produced				
Annual (million gallons)	15	12	14	11
Life cycle (million gallons)	190	160	180	140

a. WSRC (1998d, 2000a).
b. WSRC (1998e).
c. WSRC (1998f).
d. WSRC (1998g).
e. Includes 0.154 million gallons/yr solids slurry and 0.523 million gallons/yr strip effluent solution, assuming no evaporation (WSRC 1998b); analogous life-cycle outputs shown.
f. Includes 2 million gallons monosodium titanate slurry and 0.6 million gallons crystalline silicotitanate slurry (WSRC 1998b, 1998e).
Note: Material balance estimates are ± 25 percent.

pumps, filter systems) to implement any alternative. Preconceptual designs are included in this section. The facilities would be sized to contain large feed storage and product hold tanks to ensure an average daily processing rate of 25,000 gallons of salt solution. The large tanks would also enable continuous operations of salt processes by separating them from the batch processes of the Tank Farm operations. Transfer facilities required to direct the flow of process streams among the various facilities are described in Appendix A.

Because the facilities required for any of the action alternatives are very similar, this discussion is relevant to all four alternatives.

New shielded process buildings would be constructed, regardless of the salt processing alternative selected. The preferred site for the process buildings for the Small Tank Precipitation, Ion Exchange, and Solvent Extraction alternatives is Site B in S Area. The process building for the Direct Disposal in Grout alternative would be in Z Area. Direct Disposal in Grout would require a shielded building for the MST treatment to remove strontium and actinides from the salt solution and to provide enhanced shielding and remote handling for grout operations. In each case, the process buildings would be constructed of reinforced concrete and contain shielded cells designed to handle highly radioactive materials.

L6-25

The building specifications would be similar for each of the four salt processing alternatives, requiring a somewhat smaller building with Direct Disposal in Grout. Preliminary design dimensions are provided in Table 2-5. A more detailed description of the process facilities for each alternative, including preliminary floor plans, is provided in Appendix A.

2.7.4 SUPPORT FACILITIES

Each alternative would require support facilities including a service and office building and an electrical substation. Support facilities are described in Appendix A.

2.7.5 SALTSTONE VAULTS

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As shown in Table 2-3, as many as 16 additional saltstone disposal vaults would be constructed in addition to the two existing vaults in Z Area to support the salt disposal for each of the

Table 2-5. Building specifications for each action alternative.[a]

	Process Alternative			
	Small Tank Precipitation	Ion Exchange	Solvent Extraction	Direct Disposal in Grout
Length, ft.	310	280	300	220
Width, ft.	140	140	120	120
Height, ft.	60 (100 ft. bay)	60 (100 ft. bay)	70 (110 ft. bay)	60 (90 ft. bay)
Depth below grade, ft.	40	40	40	20
Floor Area, ft.^{2}				
including processing cells	66,000	60,000	62,000	54,000
excluding processing cells	50,000	48,000	48,000	43,000
Volume, ft.^{3}				
including processing cells	4,500,000	4,200,000	4,500,000	1,800,000
excluding processing cells	3,900,000	3,600,000	3,900,000	1,200,000
Processing cell floor area, ft.^{2}	16,000	12,000	13,000	11,000
Processing cell volume, ft.^{3}	640,000	550,000	600,000	570,000

Source: WSRC (1998c).
a. Building specifications rounded to two significant figures.

alternatives (Figure 2-2). The concrete vaults would be 300 feet long by 200 feet wide by 25 feet high. Each vault would consist of six cells, 100 feet long by 100 feet wide. Due to the heat generated during grout solidification, the cells in each vault would be filled in a rotation that would meet grout cooling requirements. All vaults would be equipped with cameras and lights to monitor filling and thermocouple assemblies to monitor heat generation during the curing process. After each batch of grout was transferred to a vault, the grout transfer lines, Saltstone Hold Tank, and Grout Feed Pumps would be flushed to the vault to remove any residual grout material. As with the original saltstone vaults, the additional vaults would be constructed at or somewhat below grade and covered over with soil after vault closure for additional shielding. Figure 2-8 illustrates how Z Area would look after vault closure.

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For the Direct Disposal in Grout alternative, 13 additional vaults would be constructed in Z Area. Because the grout would contain large amounts of radioactive cesium, the disposal procedure for this alternative would differ from that of the other three alternatives. Each vault would have a 500-cubic-foot-per-minute ventilation system, equipped with high-efficiency particulate air filters that would operate to control contamination during the cell-filling process. Radiation monitors and dampers would be included.

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TC

2.7.6 PILOT PLANT

After DOE selects a salt processing alternative, a Pilot Plant would be designed and constructed to provide pilot-scale testing of process technology before construction and operation of the full-scale facility. DOE intends to construct and operate a Pilot Plant only for the selected alternative. However, in the event that DOE decides to demonstrate more than one technology, the Pilot Plant units would be developed and operated in series. The Pilot Plant would serve primarily to demonstrate overall process objectives. Laboratory-scale testing to address key technical uncertainties was completed in April 2001, but some uncertainties could not be fully addressed without pilot-scale tests using actual waste from the SRS HLW system. Initial pilot-scale demonstrations would provide data required to perform preliminary and final design of the full-scale facility. Extended operation cycles, with

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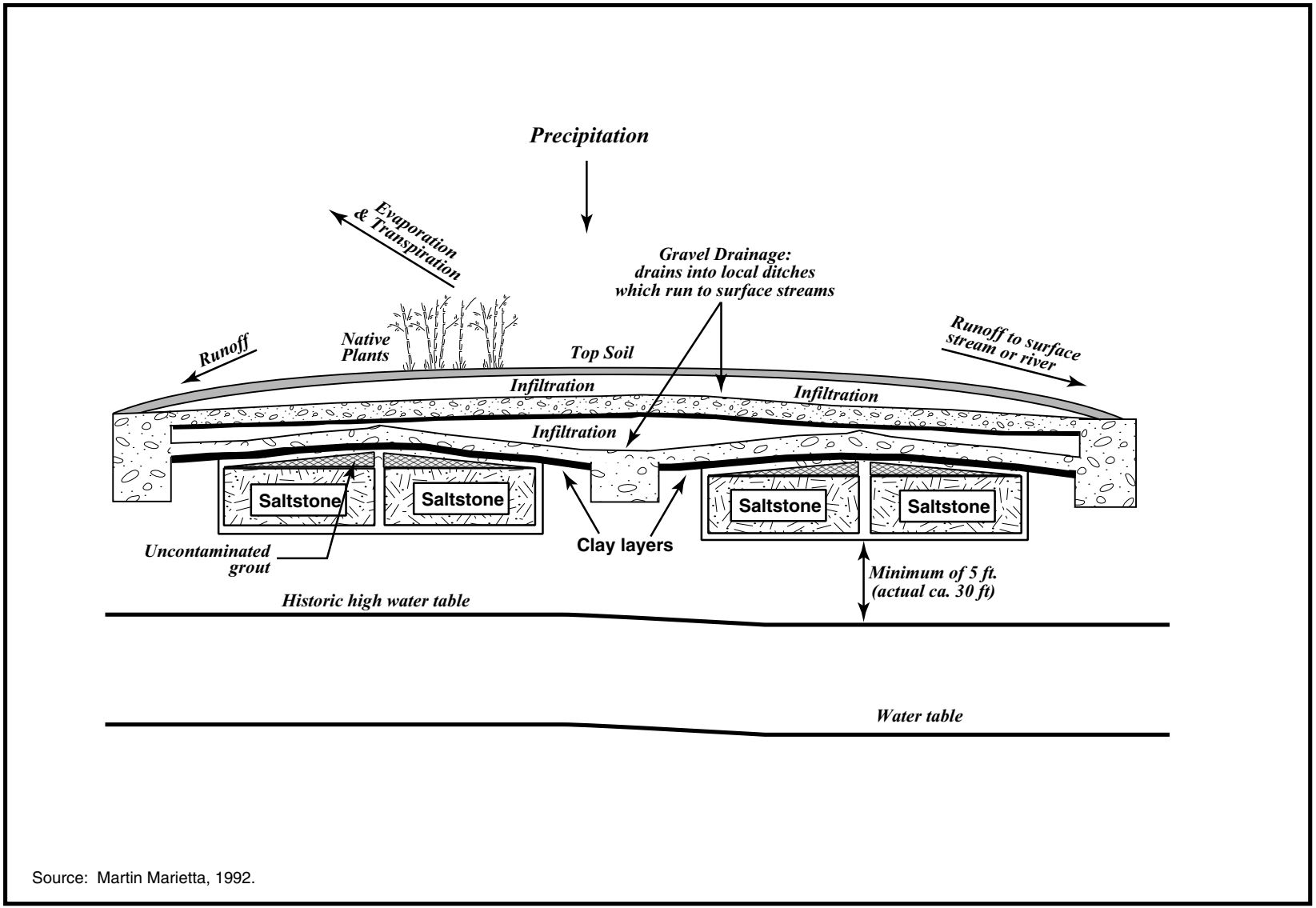

Source: Martin Marietta, 1992.

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Figure 2-8. Cross-section diagram of vault closure concept.

varying operating parameters and feed blends, would provide needed process details for full-scale design and start of construction. Unit operations and their integration into a coordinated process would be demonstrated, process extremes and upset conditions would be investigated, equipment operation would be evaluated, and process streams would be qualified for full-scale operations. The Pilot Plant would also provide a facility for training engineers and operators.

The Pilot Plant components would be sized to operate on a scale from 1/100 to 1/10 of a full-sized facility.

The Pilot Plant would be located in an existing process area well within the SRS boundary. Candidate sites include the Late Wash Facility in H Area (see Figure 2-1), near DWPF in S Area, or in another area near the location of the proposed full-scale facility.

Detailed design and construction of the Pilot Plant would be initiated upon selection of the salt processing alternative and operation would extend through completion of final design and startup of the full-scale facility. Principal process operations would be conducted inside shielded cells. Scaled-down hardware, instrumentation, and controls appropriate to the selected process would be installed. The units would use modular designs to facilitate remote installation and modification of the process equipment.

Services that would be provided include utilities, process chemicals, ventilation systems, and personnel support. An appropriate chemical storage area would be developed, with isolation of acids, caustics, oxidizing and reducing agents, and other incompatible reactants. Ventilation systems would be operated so that airflow was from areas of low contamination to those of higher contamination potential.

Operations would be conducted in accordance with appropriate safety documentation requirements, including provisions for safe and orderly emergency shutdown. Emergency equipment and procedures would ensure that operations were maintained within constraints analogous to those of the full-size facility.

The generation and dispersion of radioactive and hazardous materials would be minimized. Process waste would be disposed of at appropriate Site locations, such as the HLW Tank Farms, DWPF, Saltstone Manufacturing and Disposal Facility, Effluent Treatment Facility, or the low-level waste vaults.

Detailed examples of proposed test objectives are given in Appendix A.

2.7.7 FACILITY DECONTAMINATION AND DECOMMISSIONING

Any new facility would be designed and constructed to limit the generation and dispersion of radioactive and hazardous materials and to facilitate ultimate decontamination and decommissioning or reuse. Areas of the facility that might become contaminated with radioactive or other hazardous materials under normal or abnormal operating conditions would incorporate design features to simplify their decontamination. Items such as service piping, conduits, and ductwork would be minimized in these areas and arranged to facilitate decontamination. Facility design would include a dedicated area for decontamination of tools and some equipment. Design features that would be incorporated into the facility include the following:

- Modular confinement would be used for radioactive and hazardous materials to preclude contamination of fixed portions of the structure

- Long runs of buried piping that would carry radioactive or hazardous materials would be minimized to the extent possible, and provisions would be included in the design that would allow testing of the integrity of joints in buried pipelines